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THE EFFECT OF SEA BARRIERS UPON ULTIMATE DRAINAGE

THE causes which determine the location of river courses in the neighborhood of their discharge into the sea, where the currents are slow and their power of erosion small, are often quite insignificant.

If, however, a stream once becomes established in any given course, and the region through which it flows becomes elevated, its sluggish current at once becomes active and forms a valley of greater or less depth. Its tendency through subsequent changes in the land level is to remain in the valley approximately as originally formed. This tendency is especially strong if this original valley is parallel with the strike of the strata.

It is not the purpose of the present paper to discuss the development of intricate drainage systems along structural lines, and through long periods of time, but simply to suggest that a drainage system may sometimes have a portion of its course fixed, by spits and barrier beaches along the coast line, at the same time that the sediments which are to form the rocks of its future drainage area are being deposited; and also that the drainage when established thus early may remain more or less fixed through its subsequent history.

Along coast lines generally, and especially along those of gently sloping coastal plains, spits, bars, and barriers are more or less common. For our present purposes these may all be spoken of as barriers, and so far as the present paper is concerned it does not matter whether they are composed of sand, gravel, or coral; neither do the forces by which they are built up need to be discussed.

The lagoons between the barriers and the shore vary in length with the barriers, from a few hundred yards to many miles. Such lagoons are parallel to the shore and usually

almost at right angles to the course of the drainage entering them.

The drainage from the land must pass through these lagoons, often for almost their entire length before it can reach the sea through gaps in the barriers or around their ends. Thus it happens that long, low barriers, often of soft sand, and of insignificant height, which if inland would be slight obstacles to erosion, often control large drainage areas (Fig. 1).

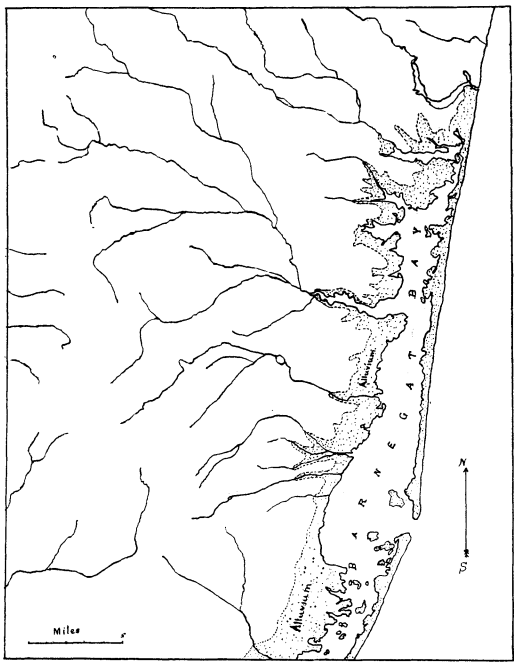

FIG. 1.—Barnegat Bay on the coast of New Jersey. The drainage, at present deflected by the barrier, passes through the bay and into the ocean.

Excellent examples of drainage controlled by barriers are to be found developed to a greater or less extent along the coasts of almost all countries. Along our own coasts the most marked examples are the streams flowing from Texas into the Gulf of Mexico; Indian River along the east coast of Florida; and the

streams emptying into Albemarle, Pamlico, and neighboring sounds. The drainage in all these localities is deflected many miles. Many less marked instances of deflected streams may be seen upon almost any map of a long coast line.

The writer's attention has been called by Dr. J. C. Branner to the stone reefs along the coast of Brazil. These reefs bear

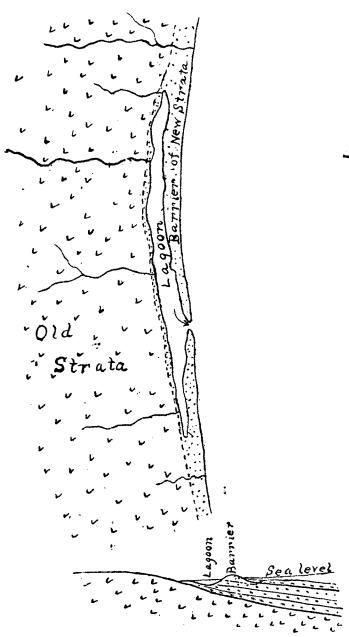

FIG. 2

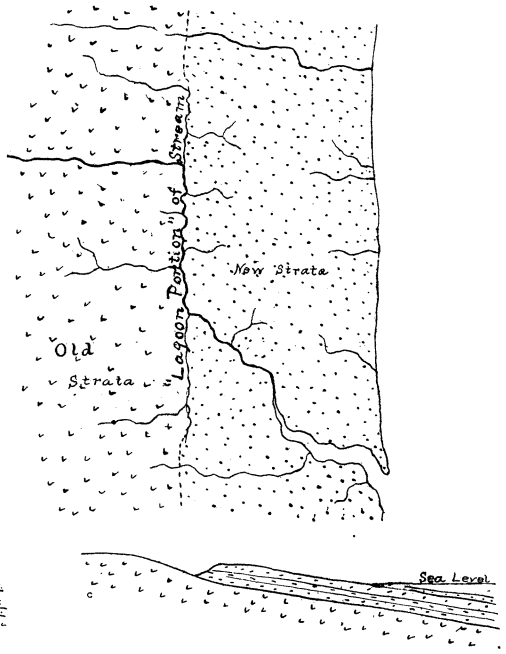

FIG. 3

FIG. 2 shows a shore line whose drainage is deflected by a barrier. The cross-section shows the relations existing between the barrier, lagoon, new, and older strata.

FIG. 3 shows the arrangement of drainage, as represented in Fig. 2, after the elevation of the land. The "lagoon portion" of the stream is here shown as being directly along the contact between the newer and older groups of strata.

the same relation to the shore as ordinary sand barriers, and they are probably old barriers whose sands early became cemented. In such cases of early solidification, the "lagoon" portion of the resulting land stream is, of course, held in position much more firmly than in the case of loose sands.

Shore deposits usually have a slight seaward dip. It happens, therefore, that the streams entering lagoons behind barriers may not only have their courses determined early in their history, and that subsequent erosion after the land becomes elevated tends to deepen the channel in the position determined, but also that this position is parallel with the strike of the strata. The subsequent tendency of the stream, therefore, is to remain in this original course established for it by the lagoon, as shown in Figs. 2 and 3.

If the coast, along which such stream deflection occurs, happens to be rising, or if the barriers are being added to from the seaward side, the barriers, at first narrow and low, may become gradually wider and higher and finally form a considerable land area. In this new area a new drainage system will develop, a portion of it being drained landward to its old lagoon, the rest draining either directly or through a new lagoon, into the ocean, as shown in Figs. 3 and 4.

If the land level remains unchanged, the lagoon is left inland and controls the drainage of the region on its landward side with little or no tendency toward erosion. If, however, the land becomes slowly elevated, the old "lagoon portion" becomes an active stream and cuts out a channel in and along the strike of the new rocks. As the shore becomes more and more elevated, and the stream is left further inland, this portion of the channel becomes more firmly established in its course. Thus it becomes an inland stream, which had a greater or less portion of its length originally established parallel with the coast, with the contact between groups of strata and also with the strike of the rocks, and not across the strike or outcrop, as is so commonly taken for granted for the original courses of streams. (Fig. 3.)

It is obvious from what has been said that the "lagoon portions" of streams will be determined in a direction approximately parallel with the general direction of the contacts of the newly-formed geologic groups; they may be directly along this line, or they may be several miles on either side of it.

Fig. 1 may be taken as a type to illustrate this. Here the

barrier of "alluvium" enclosing Barnegat Bay on the coast of New Jersey is from three to five miles from the contact between the "alluvium" and the older beds of gravel, sands, and clays. If Barnegat Bay were silted up by sediments from the landward

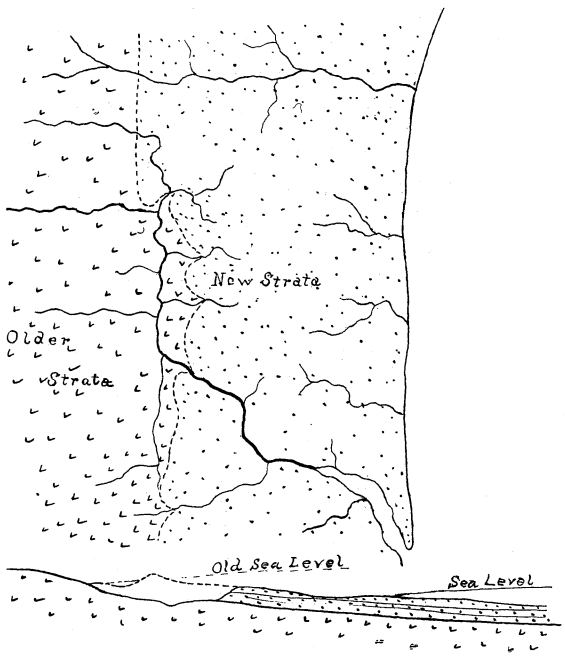

FIG. 4.

FIG. 4 is a further development of Fig. 3; the "lagoon portion" of the old stream having for the most part settled itself down in the underlying strata. The contact between the newer strata and the older being shifted seaward by erosion, the line of contact is some distance to the seaward from the stream. If the underlying older beds are very hard, the stream might continually shift itself along the line of contact, instead of cutting down into the hard beds below. A part of the old "lagoon portion," instead of cutting down into the underlying rocks, is shown as having been shifted down the dip of the newer beds, and as flowing parallel with the contact but to the seaward of it.

side, its lagoon might be shifted close up against the barrier. If, under these circumstances, this coast should be elevated and the shore line should be shifted some miles seaward, the "lagoon portion" of the resulting stream would be approximately parallel

to the strike of the rocks, and also to the upper and lower contacts of the particular group of strata formed, though several miles removed from either of those contacts.

On the other hand, a stream flowing parallel with the contact and not far removed from it might cut down completely through the series of strata by which its course was originally determined, and reach the older underlying rocks. Under such circumstances the newer beds through and along the edges of which the stream originally flowed, would in time be removed by erosion for some considerable distance from the line of contact, as shown in Fig. 4.

It is, of course, difficult to point with certainty to streams at present far inland that have had their courses originally determined in the manner suggested. This explanation offers itself, however, for streams that now flow parallel to and in the neighborhood of contacts between sets of beds of different ages, as also for streams flowing parallel to preëxisting coast lines. It is not improbable that many streams flowing with the strike of strata, and whose courses have been attributed to stream capture, owe these courses to the simple fact of their having been primarily established in that position as here suggested. Many such streams may be seen on any detailed geologic and drainage map of our eastern and southern coastal region, though they are by no means limited to such regions.

This explanation is suggested as a probable one in accounting for the sudden southwest deflection of the Delaware River at Bordentown, N. J., and the Potomac near Washington, and for the sudden turn of the Susquehanna into the upper portion of Chesapeake Bay, which may be considered as its extension.

The same explanation is suggested also in regard to the Tennessee River for the lower portion of its course where it flows northward through west Tennessee and Kentucky.

Black River, in Arkansas, flows for almost its entire length near the line of contact between Tertiary and Paleozoic rocks. This stream may have had its course originally established,

parallel to the old coast line in much the same way that Indian River, Florida, has its course fixed at the present time.

Many others could be mentioned, but these serve to show the character of the drainage that might be expected from the suggested causes.

It is not meant to imply by the foregoing remarks that all barriers that may be formed will exercise control on the ultimate drainage. Probably most of those formed are quickly destroyed as the shore line encroaches or recedes. It is hardly reasonable to suppose, however, that all barriers formed through past geologic ages have been disposed of thus easily.

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